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ABSTRACT. The nesting habitat of the Clapper Rail (*Rallus longirostris*) is not well studied in the southeastern United States. We documented Clapper Rail nest characteristics and surrounding habitats near Brunswick on the Georgia coast. Of 159 nests found, only 29 were active. Although some nests may have been abandoned or never used, many could have been depredated. Nests were constructed farther away from tidal influences than in those populations studied in the mid-Atlantic region of the United States. Clapper Rails also tended to nest near tidal pools as frequently as tidal creeks, contrasting with other Atlantic coast studies. The greater tidal amplitude of Brunswick as compared to the mid-Atlantic coast may explain this finding. Tidal-creek nests were found farther away from, and were associated with taller vegetation near the banks of, a water source than tidal-pool nests. While nest placement differed based on habitat characteristics in this study, nest-structure morphometrics were similar between tidal-creek and tidal-pool habitats and were consistent with those found in other regions of the country.

SINOPSIS. **Características de los nidos de *Rallus longirostris* en la costa de Georgia**
El habitat de anidamiento de *Rallus longirostris* no ha sido bien estudiado en el sureste de los Estados Unidos. Documentamos las caracteísticas del habitat de anidamiento y de los alrededores de esta especie en Brunswich, Georgia. De 159 nidos encontrados solo 29 estaban activos. Aunque algunos de estos nidos muy bien pudieron ser abandonados o nunca utilizados, muchos de estos pudieron haber sido depredados. Los nidos fueron constuidos más lejos del efecto de las mareas que los estudiados en la región media del Atlántico. Las aves tendieron a anidar cerca de charcas formadas por las mareas y de arroyos también formados por esta, lo que contrasta con los estudios hechos en el Atlántico. La mayor amplitud de las mareas en Bruanswick muy bien pudieran ser la causa de las diferencias. Los nidos en arroyos formados por las mareas se encontraron más lejos y estuvieron asociados con vegetación de mayor altura que quellos encontrados en las charcas de mareas. Aunque la localización del nido vaió con el habitat, la morfometría estructural del nido resultó similar en ambos habitats y con otros encontrados en otras regiones del pais.

Key words: Georgia, *Rallus longirostris*, *Spartina alterniflora*, tidal-creek, tidal-pool

Salt marshes along the Atlantic coast of North America are fragile, economically important ecosystems that provide food, shelter, and breeding grounds for wildlife. The Clapper Rail (*Rallus longirostris*) is a secretive marsh bird that inhabits coastal salt marshes throughout the United States. It has been used as an indicator species for estuarine marsh health (Vanvelzen and Kreitzer 1975; Lonzarich et al. 1992; Jarman et al. 1993; Kannan et al. 1998) because of its strong site fidelity, small home-range size during the breeding season (approx. 1 ha in the southeast; Blandin 1963), and predictable diet consisting primarily of marine invertebrates (Oney 1951; Terres 1991). In the southeast this bird is a popular game species with hunters often achieving their bag limits (K. Giovengo, pers. comm.). This makes it increasingly important to understand Clapper Rail behavior at the microhabitat level in part to determine its susceptibility to contaminant uptake and at what scales it can be used as an indicator species.

Although the natural history of this species is well documented in the literature, the Clapper Rail's nesting habits and activity patterns vary based on climate and ecosystem structure (Meanley 1985). Typically, estuaries of the southeast consist of large expanses of salt marsh cord grass (*Spartina alterniflora*; hereafter *Spartina*) interspersed throughout with small patches of needle rush (*Juncus roemerianus*; hereafter *Juncus*). Tidal creeks form branching networks that flood and drain with tidal fluxes. Marshes are also characterized by tidal pools, areas that flood at high tide and typically are exposed and isolated during low tide. These pools often have islands that remain dry or are shallowly flooded at high tide. Clapper Rails nest in tidal-creek

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and tidal-pool habitats in nests consisting of substantial platforms of dry vegetation built-up to avoid tidal flooding (Shuford 1993). A canopy or dome of interwoven vegetation that conceals the eggs and a vegetative ramp leading to the substrate are sometimes present (Eddleman and Conway 1998). We documented Clapper Rail nest characteristics to determine what habitat parameters are preferred. The specific objectives of our study were to describe the structure of Clapper Rail nests in the estuaries typical of coastal Georgia and determine if nest characteristics differ between two habitats (tidal-creek and tidal-pool).

METHODS

Study area. This study was conducted in two marshes near Brunswick, Georgia (Glynn County; 31°10′N, 81°30′W), one associated with the Turtle River and the other with the South Brunswick River. This area is situated near a former chemical plant that has discharged mercury and PCB's into the Brunswick estuary (Gardner et al. 1978; Kannan et al. 1998). Both areas were searched for Clapper Rail nests from 15 April to 31 May 2000. The vegetation and habitat structure were consistent with most other southeastern salt marshes, comprised mainly of *Spartina* interspersed with small patches of *Juncus* intersected by tidal creeks.

Nest searching and classification. We searched each marsh systematically, covering areas both near and far from tidal creeks. Each nest site was identified as being associated with tidal-creek or tidal-pool areas based on its closest tidal water source. Other rail species that occupied the marsh were Soras (*Porzana carolia*) and King Rails (*Rallus elegans*). We had no difficulties discerning Clapper Rail nests because Sora eggs are much smaller than Clapper Rail eggs, and their nests are structurally different (Taylor 1998). In fact, no Sora nests were ever found. King Rails may interbreed with Clapper Rails in the southeast (Meanley 1985); however, no egg measurements (Taylor 1998) on active nests definitively indicated any King Rail nests. Based on four years studying Clapper Rails in this marsh in ongoing toxicological studies, all nests found during the breeding season were considered to be from the present year as winter storms and high tides destroy all nests from the previous year. We classified three types of nests: brood, active incubation, and non-active incubation nests. Brood nests have been described as identical to, and found very close to, the incubation nest but lack a canopy (Adams and Quay 1958; Eddleman and Conway 1998). Brood nests found later in the season the year this study was performed were lower to the ground and did not have a canopy. Only a few nests meeting these criteria were found during the study period and were not used. All possible incubation nests were measured, their status (eggs present or absent) was recorded, and they were classified as being active or non-active.

Habitat classification. Tidal-creek areas were those where the closest tidal influence to the nesting habitat was a small steep-banked tidal drain. Tidal pools were those areas that commonly flooded at high tide but consisted of an exposed mud flat with short ($<$20 cm) exposed vegetation at low tide. During high tide all areas of the marsh flooded; however, the steep banks associated with the tidal creeks and the higher areas associated with tidal pools did not flood as deeply and did not completely flood during half moon lunar phases. Nests were found in these high marsh areas. Six measurements were taken at each nest: (1) height of the nest platform above the substrate, (2) outside maximum diameter of the nest platform, (3) height of the nest canopy (measured from the platform), (4) maximum height of vegetation directly next to the nest (to within $<$0.5 m), (5) maximum height of the vegetation bordering the nearest tidal influence (tidal creek or tidal pool; vegetation was always higher near these water sources), and (6) distance to nearest tidal influence (tidal creek or tidal pool).

Statistical analyses. We examined whether nest measurements were distributed normally using the Shapiro-Wilk statistic (SAS Institute Inc. 2000). All variables except height of platform were non-normal ($P < 0.05$). We log-transformed all non-normal variables, which made their distributions normal. We examined differences in individual nest measurements between nest habitat types (e.g., tidal influence) using a 2-way analysis of variance (ANOVA) model with nest activity and study site as main treatment effects and their interaction effect (SAS Institute 2000). Study site was never a significant variable (P's > 0.20), therefore it was

Table 1. ANOVA results for Clapper Rail nest (N = 159) measurements using location (tidal-creek and tidal-pool habitats) and nest activity (egg presence) as main treatment effects.

Measurement	Degrees of freedom[a]	Location		Nest activity	
		F-value	P-value	F-value	P-value
Platform height	1,156	0.00	0.95	3.72	0.06
Platform diameter	1,156	1.03	0.31	5.63	0.02
Canopy height[b]	1,116	3.46	0.07	0.00	0.97
Distance to tidal influence	1,156	28.87	<0.0001	0.03	0.86
Height of vegetation near nest	1,156	1.89	0.17	1.10	0.30
Height of vegetation near water	1,156	23.47	<0.0001	0.03	0.87

[a] Degrees of freedom refer to both location and nest activity.
[b] Not all nests had a distinctive canopy.

dropped from all models. Additionally, no interaction effects were significant (Ps $>$ 0.20) and were dropped from all models. All statistical tests were considered significant at $P \leq 0.05$. Means and standard errors are presented as back-transformed values of log Least Square (LS) means estimates (i.e., geometric means).

RESULTS

A total of 159 nests were found between 15 April and 31 May 2000. Seventy-two nests were associated with tidal-pool habitats and 87 with tidal-creek habitats. Twenty-nine of the 159 nests were active (had eggs), and based on nest monitoring, were identified as actively attended. Fifteen of these were in tidal-pool habitats and 14 were in tidal-creek habitats. Nest activity had no effect on any model except for nest diameter with active nests having a larger diameter (Least Square (LS) mean = 26.03; SE = 1.04 cm) than non-active nests (LS mean = 23.65; SE = 1.01 cm; based on back-transformed data).

Distance to nearest tidal influence differed between nests associated with tidal-creek versus tidal-pool habitats (Table 1; Fig. 1). Clapper Rails using tidal-creek habitats built nests at greater distances from the open-water vegetation interface than those using tidal-pool hab-

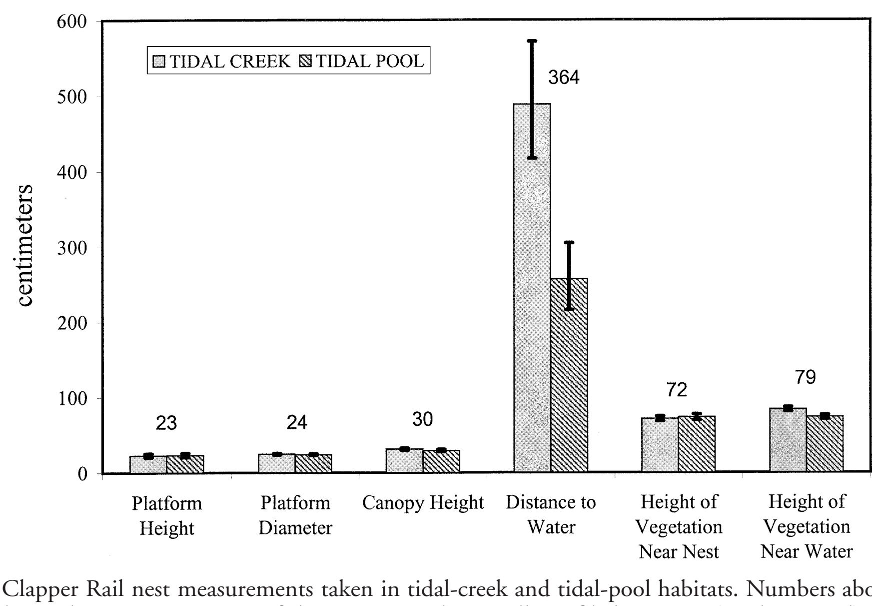

Fig. 1. Clapper Rail nest measurements taken in tidal-creek and tidal-pool habitats. Numbers above the bar graph indicate the geometric mean of the entire sample regardless of habitat type (creek vs. pool). Error bars represent the 95% confidence interval for each category.

itats (Table 1; Fig. 1). Most nests associated with tidal pools were within 1–4 m from this interface, whereas nests associated with tidal creeks were usually within 3–8 m. Maximum height of *Spartina* bordering the nearest tidal influence was significantly greater for tidal-creek nests than for tidal-pool nests (Table 1; Fig. 1). Specifically, most *Spartina* stands near tidal pools were less than 80 cm while most of the *Spartina* stands near tidal creeks were between 70 cm–100 cm tall.

The height of the tallest *Spartina* at the nest was found to be within 60–80 cm, with less than 20% of the nests having taller vegetation. Most nest platform heights were between 25–40 cm. Only 20% of the nests had a height greater than 40 cm. Diameter of the nest platform was usually within 20–35 cm, with only 20% of nests having a larger diameter. Height of the canopy above the nest platform was found usually within 24–34 cm, with less than 20% of the nests having canopies greater than 34 cm.

DISCUSSION

Optimal Clapper Rail nesting habitat is thought to represent a trade-off between sites of higher elevations with sparse cover and lower elevations with dense cover (Meanley 1985; Eddleman and Conway 1998). Nests need to be constructed in habitats where flooding by tides and storm surges can be avoided, yet be in vegetation adequately dense to support the moderately large nest and to be hidden from predators (Storey et al. 1988). On the Atlantic coast, habitats suitable for nesting seem to be influenced by tidal fluxes. When constructing a Habitat Suitability Index (HSI) for Clapper Rails, Clark and Lewis (1983) indicated that most nests on the Atlantic coast occur within 5 m of water. Other studies on the Atlantic coast showed that nests were readily found in the taller *Spartina* near tidal creeks (Stewart 1951; Adams and Quay 1958; Meanley 1985). However, these studies contrast with ours in that most tidal-creek nests we found were ≥5 m away from the tidal influence and usually were in *Spartina* that was 60–80 cm tall. The shallower slopes of the tidal-pool islands compared to the steep banks of the tidal creeks could explain why tidal-creek nests were found farther away from a tidal influence than tidal-pool nests. Further, more tidal-pool habitats are situated at greater distances from the main tidal channels, and therefore nests near these habitats are less likely to be influenced by very high tides or storm surges. These distinctions may be explained by the difference in tidal amplitude between Brunswick, Georgia, and the mid-Atlantic coast. For example, Brunswick has an average tide of 1.12 m while Chincoteague, Virginia, has an average tide of 0.42 m (NOAA 2000). Therefore, because Brunswick's tides are higher than those farther north, one would expect to find nests at greater distances from the tidal influence to protect them from flooding.

Since only 29 of 159 Clapper Rail nests had eggs in them (e.g., active), interpretations of nest site selection must be made cautiously. Meanley (1985) discusses "symbolic" or "courtship" nest building by males. These courtship nests were not used as the incubation nest later by the breeding pair and would have been classified as non-active in our study. It is unclear to what extent courtship nest building occurs and therefore nests could not be unambiguously identified as courtship nests during nest searches. Some non-active nests could have been courtship nests, while others could have been depredated or abandoned due to factors such as flooding. Although there are many potential reasons for nest failure, it may be tempting to consider that failure due to predation or flooding indicates that habitats associated with these nests are "sub-optimal," and to also consider courtship nests as associated with sub-optimal conditions if courtship nests are built by less experienced birds. However, since approximately the same proportion of non-active nests and active nests were found in tidal-creek and tidal-pool habitats, there is no evidence to believe that one habitat type would be better than another. Since we have no information regarding nest fate, our discussion is limited only to nest site selection. However, active nests had larger platform diameters than non-active nests. Since the nesting pair constantly tends the nests, non-active nests will wear over time by flattening or distortion. If a nest was never used, or used briefly, it may not be as robust as one that had been attended to for the full incubation period. In contrast, if most of our non-active nests were never used for incubation, additional morphometrics should also differ based on activity.

Although the habitat characteristics associated with Clapper Rail nests from Brunswick contrast with those from the mid-Atlantic to some degree, general nest structure is similar to those found in other regions of the country (Kosten 1982; Harvey 1988; Eddleman 1989). However, the proportion of active nests found (29 of 159 nests) was low compared to other studies (Adams and Quay 1958; Massey et al. 1984). Since renesting (often more than once) will occur following disturbance or destruction of the first nest (Blandin 1963), thereby increasing the number of empty nests present, the low proportion of active nests may be due to disturbances and predation. During the nest-search period, avian predators (e.g., crows and raptors) were often seen hunting in the marsh and on occasion stealing eggs from Clapper Rail nests. We also found egg fragments at known bird perching areas. Additionally, raccoons (*Procyon lotor*) and river otters (*Lutra canadensis*) were often encountered. Further research focusing on nesting success in these salt marsh systems is required to better understand how these southeastern Clapper Rail populations respond to disturbances.

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